

## CLAIMS

What is claimed is:

1. A medical image processing apparatus for generating a medical image by using three-dimensional volume data representing a portion in a living body, said  
5 apparatus comprising:
  - a volume data obtaining unit which obtains predetermined three-dimensional volume data including a tubular tissue;
  - a region specifying unit which specifies a region including a position on the tubular tissue in the three-dimensional volume data, at each of a plurality of  
10 such positions;
  - an extraction unit which extracts information on the tubular tissue in each of the specified regions; and
  - a medical image generating unit which generates a medical image representing the tubular tissue, based on the information extracted by said extraction  
15 unit.
2. The medical image processing apparatus according to claim 1, wherein said extraction unit includes:
  - a center specifying unit which specifies a center position of a cross section of the tubular tissue in each of the plurality of regions specified by said region  
20 specifying unit, based on the three-dimensional volume data obtained by the volume data obtaining unit; and
  - a center line specifying unit which specifies a center line of the tubular tissue in a longitudinal direction of the tubular tissue, based on the plurality of center positions specified by said center specifying unit.

3. The medical image processing apparatus according to claim 2,  
wherein:

said region specifying unit sequentially specifies regions along the  
tubular tissue; and

5 said center specifying unit specifies a center of a cross section of the  
tubular tissue in each of the regions sequentially specified by said region specifying  
unit.

4. The medical image processing apparatus according to claim 2,  
wherein:

10 said region specifying unit specifies a planar region which  
orthogonally intersects with the longitudinal direction of the tubular tissue; and

said center specifying unit specifies a center position of a cross section  
of the tubular tissue in the planar region specified by said region specifying unit.

5. The medical image processing apparatus according to claim 2, wherein  
15 said extraction unit includes:

a unit which obtains a median point represented by the three-  
dimensional volume data, of the tubular tissue in each of the plurality of regions  
specified by said region specifying unit;

a cross sectional image generation unit which generates a cross  
20 sectional image representing a cross section of the tubular tissue at a position of the  
median point obtained by said unit for obtaining a median point; and

a center specifying unit which specifies a center position of the cross  
section in the three-dimensional volume data, based on the generated cross sectional  
image.

6. The medical image processing apparatus according to claim 2, further comprising a designation reception unit which receives designation for two arbitrary points on the tubular tissue represented by the three-dimensional volume data,

wherein:

5 said region specifying unit sequentially specifies planar regions which orthogonally intersect with the longitudinal direction of the tubular tissue, at a plurality of positions between the two points along the tubular tissue; and

said center specifying unit specifies a center of a cross section of the tubular tissue in each of the plurality of planar regions specified by said region  
10 specifying unit.

7. The medical image processing apparatus according to claim 6,  
wherein:

said designation reception unit receives designation for a planar region  
which orthogonally intersects with the longitudinal direction of the tubular tissue, at  
5 one of the two designated points;

said region specifying unit sequentially specifies points which are  
apart from one another by a predetermined distance in a direction heading from the  
one point to the other point of the two points along the tubular tissue, and sequentially  
specifies planar regions orthogonally intersecting with the longitudinal direction of  
10 the tubular tissue at each of the specified points;

said center specifying unit specifies a center position of a cross section  
of the tubular tissue in each of the plurality of planar regions specified by said region  
specifying unit; and

said center line specifying unit specifies a center line of the tubular  
15 tissue in the longitudinal direction of the tubular tissue, based on the plurality of  
center positions specified by said center specifying unit.

8. The medical image processing apparatus according to claim 5,  
wherein:

the three-dimensional volume data includes three-dimensional  
coordinate information and characteristic information representing a characteristic  
5 unique to a substance at each position represented by the three-dimensional  
coordinate information; and

said cross sectional image generation unit generates an image based on  
information representing a three-dimensional coordinate position having the  
characteristic information which satisfies a predetermined condition in the three-  
10 dimensional volume data, and clarifies the cross section of the tubular tissue in the  
image.

9. The medical image processing apparatus according to claim 8,

wherein said imaging unit comprises:

a condition changing unit which changes the predetermined condition;

15 an image attribute detecting unit which detects an image attribute  
which changes in accordance with changes in the predetermined condition; and

a clarification determining unit which determines whether or not the  
cross section of the tubular tissue is clarified in an image, based on detected changes  
in the image attribute.

10. The medical image processing apparatus according to claim 9,  
wherein:

the image attribute represents an area of an image (image area);

said image attribute detecting unit detects an image area which  
5 changes in accordance with changes in the predetermined condition, and detects a  
change in the image area corresponding to the changes in the predetermined  
condition; and

said clarification determining unit determines whether or not the cross  
section of the tubular tissue is clarified, based on the detected change in the image  
10 area.

11. The medical image processing apparatus according to claim 10,

wherein said clarification determining unit determines that the cross  
section of the tubular tissue is clarified in the image, when an image appearing in a  
center of the region including the cross section become fit inside the region, and the  
15 change in the image area becomes the largest.

12. The medical image processing apparatus according to claim 5,

wherein said region specifying unit determines a position of a three-  
dimensional region to be specified next, based on the three-dimensional volume data  
which is specified by said center line specifying unit and which represents the center  
20 line of the tubular tissue.

13. The medical image processing apparatus according to claim 5,  
wherein:

said center line specifying unit specifies the center line of the tubular  
tissue as three-dimensional path data; and

5 said medical image processing apparatus further comprises an image  
generating unit which generates an image representing the tubular tissue based on the  
three-dimensional path data specified by said center line specifying unit.

14. The medical image processing apparatus according to claim 13,  
wherein said image generating unit comprises:

10 an image calculating unit which generates plural kinds of images each  
representing the tubular tissue, and calculates relative positional relationships between  
the images; and

a display control unit which displays the generated plural kinds of  
images all at once on a predetermined display device, and displays positional  
15 relationships on the displayed images by associating the relations based on the relative  
positional relationships between the images calculated by said image calculating unit.

15. The medical image processing apparatus according to claim 1,  
wherein:

said region specifying unit specifies a predetermined three-dimensional region whose center is an arbitrary point on the predetermined tubular  
5 tissue represented by the three-dimensional volume data;

said medical image processing apparatus further comprises an image  
clarifying unit which clarifies a three-dimensional image representing only the  
predetermined tubular tissue in the specified three-dimensional region, by changing  
predetermined characteristic information included in the three-dimensional volume  
10 data which constitutes a three-dimensional image obtained by data-conversion of said  
imaging unit; and

said medical image generating unit generates a predetermined medical  
image representing the predetermined tubular tissue, by using the three-dimensional  
image clarified by said image clarifying unit.



16. The medical image processing apparatus according to claim 15,  
wherein:

said image clarifying unit comprises

a closed region detecting unit which detects a closed region which  
5 constitutes the three-dimensional image obtained by data-conversion of said imaging  
unit and which includes a center of the three-dimensional region, and

a clarification determining unit which determines based on the closed  
region detected by said closed region detecting unit and the three-dimensional region  
whether or not the closed region represents only the predetermined tubular tissue; and

10 the closed region which is determined by said clarification determining  
unit as representing only the predetermined tubular tissue is regarded as the clarified  
three-dimensional image.

17. The medical image processing apparatus according to claim 16,  
wherein:

15 said closed region detecting unit detects a change in the closed region  
corresponding to changes in the characteristic information; and

said clarification determining unit determines whether or not the  
closed region represents only the predetermined tubular tissue, based on changes in  
the closed region.

18. The medical image processing apparatus according to claim 15,  
wherein:

said region specifying unit specifies a plurality of three-dimensional  
regions by setting a center of a three-dimensional region to be specified next based on  
5 the arbitrary point and/or the clarified three-dimensional image; and

said medical image generating unit generates the predetermined  
medical image representing the predetermined tubular tissue, by using three-  
dimensional images clarified in the plurality of three-dimensional regions.

19. A medical image processing method for generating an image  
10 representing a tubular tissue in a living body by using a computer, said method  
comprising:

a step of obtaining predetermined three-dimensional volume data  
including a tubular tissue;

a step of specifying a region including a position on the tubular tissue  
15 in the three-dimensional volume data, at a plurality of such positions;

a step of extracting information on the tubular tissue in each of the  
plurality of specified regions; and

a step of generating a medical image representing the tubular tissue,  
based on the extracted information.

20. The medical image processing method according to claim 19, wherein said step of extracting information on the tubular tissue includes:

a step of specifying a center position of a cross section of the tubular tissue in each of the plurality of specified regions; and

5 a step of specifying a center line of the tubular tissue in a longitudinal direction of the tubular tissue, based on the plurality of specified center positions.

21. The medical image processing method according to claim 20, wherein:

in said step of specifying a region, regions are sequentially specified along the tubular tissue; and

10 in said step of specifying a center position, a center position of a cross section of the tubular tissue in each of the regions sequentially specified is specified.

22. The medical image processing method according to claim 20, wherein:

in said step of specifying a region, a planar region which orthogonally intersects with the longitudinal direction of the tubular tissue is specified; and

15 in said step of specifying a center position, a center position of a cross section of the tubular tissue in the specified planar region is specified.

23. The medical image processing method according to claim 20, wherein said step of extracting information includes:

a step of obtaining a median point of the tubular tissue represented by  
20 the three-dimensional volume data in each of the plurality of specified regions;

a step of generating a cross sectional image representing a cross section of the tubular tissue at a position of the median point obtained in said step of obtaining a median point; and

a step of specifying a center position of the cross section in the three-  
25 dimensional volume data, based on the generated cross sectional image.

24. The medical image processing method according to claim 20, further comprising a step of receiving designation for two arbitrary points on the tubular tissue represented by the three-dimensional volume data,

wherein:

5 in said step of specifying a region, planar regions orthogonally intersecting with the longitudinal direction of the tubular tissue are sequentially specified at a plurality of positions between the two points along the tubular tissue; and

in said step of specifying a center position, a center position of a cross  
10 section of the tubular tissue in each of the plurality of specified planar regions is specified.

25. The medical image processing method according to claim 24, wherein:  
in said step of receiving designation, designation for a planar region  
orthogonally intersecting with the longitudinal direction of the tubular tissue at one of  
15 the two designated points is received;

in said step of specifying a region, points apart from one another by a  
predetermined distance are sequentially specified along the tubular tissue in a  
direction heading from the one point to the other point of the two points, and planar  
regions orthogonally intersecting with the longitudinal direction of the tubular tissue  
20 at the specified points are sequentially specified;

in said step of specifying a center position, a center position of a cross  
section of the tubular tissue in each of the specified planar regions is specified; and

in said step of specifying a center line, a center line of the tubular  
tissue in the longitudinal direction of the tubular tissue is specified based on the  
25 specified center positions.

26. The medical image processing apparatus according to claim 23,  
wherein:

the three-dimensional volume data includes three-dimensional  
coordinate information and characteristic information representing a characteristic  
5 unique to a substance at each position represented by the three-dimensional  
coordinate information; and

in said step of generating a cross sectional image, an image is  
generated based on information representing a three-dimensional coordinate position  
having the characteristic information satisfying a predetermined condition in the  
10 three-dimensional volume data, and the cross section of the tubular tissue is clarified  
in the image.

27. The medical image processing method according to claim 26, wherein  
said step of generating a cross sectional image includes:

a step of changing the predetermined condition;  
15 a step of detecting an image attribute which changes in accordance  
with changes in the predetermined condition; and

a step of determining whether or not the cross section of the tubular  
tissue is clarified in an image, based on detected changes in the image attribute.

28. The medical image processing method according to claim 27, wherein:  
20 the image attribute represents an area of an image (image area);

in said step of detecting an image area which changes in accordance  
with changes in the predetermined condition, and detects a change in the image area  
corresponding to the changes in the predetermined condition; and

in said step of determining whether or not the cross section of the  
25 tubular tissue is clarified, based on the detected change in the image area.

29. The medical image processing method according to claim 28,  
 wherein said step of determining that the cross section of the tubular  
 tissue is clarified in the image, when an image appearing in a center of the region  
 including the cross section become fit inside the region, and the change in the image  
 5 area becomes the largest.

30. The medical image processing method according to claim 23,  
 wherein said step of determining a position of a three-dimensional  
 region to be specified next, based on the three-dimensional volume data which is  
 specified in said step of specifying the center line of the tubular tissue.

10 31. The medical image processing method according to claim 23, wherein:  
 said step of specifying the center line of the tubular tissue as three-  
 dimensional path data; and  
 said step of generating an image representing the tubular tissue based  
 on the three-dimensional path data specified in said step of specifying the center line  
 15 of the tubular tissue.

32. The medical image processing method according to claim 31,  
 wherein said step of generating an image comprises:  
 a step of generating plural kinds of images each representing the  
 tubular tissue, and calculates relative positional relationships between the images; and  
 20 a step of displaying the generated plural kinds of images all at once on  
 a predetermined display device, and displays positional relationships on the displayed  
 images by associating the relations based on the relative positional relationships  
 between the images calculated in said step of generating plural kinds of images.

33. The medical image processing method according to claim 19, wherein:
- said step of specifying a predetermined three-dimensional region whose center is an arbitrary point on the predetermined tubular tissue represented by the three-dimensional volume data;
- 5           said step of clarifying a three-dimensional image representing only the predetermined tubular tissue in the specified three-dimensional region, by changing predetermined characteristic information included in the three-dimensional volume data which constitutes a three-dimensional image obtained by data-conversion; and
- said step of generating a predetermined medical image representing
- 10 the predetermined tubular tissue, by using the three-dimensional image clarified in said step of clarifying an image.
34. The medical image processing method according to claim 33, wherein:
- said step of clarifying an image
- a step of detecting a closed region which constitutes the three-
- 15 dimensional image obtained by data-conversion and which includes a center of the three-dimensional region, and
- a step of determining based on the detected closed region and the three-dimensional region whether or not the closed region represents only the predetermined tubular tissue; and
- 20           the closed region which is determined as representing only the predetermined tubular tissue is regarded as the clarified three-dimensional image.

35. The medical image processing method according to claim 34, wherein:  
said step of detecting a change in the closed region corresponding to  
changes in the characteristic information; and  
said step of determining whether or not the closed region represents  
5 only the predetermined tubular tissue, based on changes in the closed region.
36. The medical image processing method according to claim 33, wherein:  
said step of specifying a plurality of three-dimensional regions by  
setting a center of a three-dimensional region to be specified next based on the  
arbitrary point and/or the clarified three-dimensional image; and  
10 said step of generating the predetermined medical image representing  
the predetermined tubular tissue, by using three-dimensional images clarified in the  
plurality of three-dimensional regions.